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LIFE HISTORY OF THE SPOTTAIL SHINER (*NOTROPIS HUDSONIUS*) IN SOUTHEASTERN LAKE MICHIGAN, THE KALAMAZOO RIVER, AND WESTERN LAKE ERIE

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LIFE HISTORY OF THE SPOTTAIL SHINER (*NOTROPIS HUDSONIUS*) IN SOUTHEASTERN LAKE MICHIGAN, THE KALAMAZOO RIVER, AND WESTERN LAKE ERIE [1]

By LaRue Wells and Robert House

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CONTENTS

	Page
Abstract	iv
Introduction	1
Materials and methods	1
Depth and temperature distribution	2
Age composition and sex ratio	3
Annual growth	4
Seasonal growth	7
Length-weight relation	7
Reproduction	8
References	10

ABSTRACT

In southeastern Lake Michigan spottail shiners in samples ranged from ages O to V, but most were in age groups I–IV. In the Kalamazoo River (a tributary of southeastern Lake Michigan) age group II was commonest in the catches, and no fish older than age IV were sampled. In western Lake Erie, most shiners were in age groups O–II, and none were older than age IV. Mortality of males was much higher than that of females after age II in Lake Michigan and after age I in Lake Erie.

Growth of spottail shiners was fastest in western Lake Erie (125 mm at the end of the third year, sexes combined) and slowest (77 mm) in the Kalamazoo River; in all three waters growth declined rapidly after the first year. Females grew faster than males.

Young shiners started growing earlier in the year than older ones in all three waters. Males and females of the same age resumed growth at about the same time. The growing season began as early as mid-May in the Kalamazoo River and continued as late as September or early October in the other two waters.

Small spottail shiners in Lake Michigan and the Kalamazoo River weighed about the same at a given length, but at lengths greater than about 100 mm the lake fish were heavier.

In all three waters, spottail shiners matured at about the same length, and males at a somewhat smaller size than females. Smallest mature fish were 65–69 mm long, and the largest immatures were 80–84 mm. In Lake Michigan about half and in Lake Erie about three-quarters of age-I fish were mature, as were all age-II fish in both lakes. In the Kalamazoo River a few fish of age II and all of age III were mature.

The spawning season in Lake Michigan in 1964 was from late June or early July to late July, whereas in 1972, which had a colder spring, spawning occurred from mid-July to late August or early September. All shiners in the Kalamazoo River had spawned by the end of June in 1964. Lake Erie spottail shiners spawned during early June to early or mid-July in 1958.

Spottail shiners 87–143 mm long from the different waters contained 915 to 8,898 mature eggs.

LIFE HISTORY OF THE SPOTTAIL SHINER (*NOTROPIS HUDSONIUS*) IN SOUTHEASTERN LAKE MICHIGAN, THE KALAMAZOO RIVER, AND WESTERN LAKE ERIE

By LaRue Wells and Robert House

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INTRODUCTION

The spottail shiner, *Notropis hudsonius*, inhabits all the Great Lakes and many of their tributary waters (Hubbs and Lagler 1958). It is essentially a bottom form, and in the Great Lakes prefers the shallowest waters. In Lake Michigan it is most abundant in the southeastern part and in Green Bay (unpublished data, Great Lakes Fishery Laboratory and Michigan Department of Natural Resources).

The spottail shiner is an important forage fish in some waters it inhabits, but apparently not in Lake Michigan. In Lake Erie, it was found frequently in the stomachs of walleyes, *Stizostedion vitreum* (Parsons 1971; Price 1963) and occasionally in white bass, *Roccus chrysops* (Ewers 1939); in Lower Red Lake, Minn., it has been reported to be the major food of walleyes (Smith and Kramer 1964); and in four eastern North American streams it was found commonly in stomachs of smallmouth bass, *Micropterus dolomieu* (Surber 1939). In Lake Michigan the spottail shiner has been used as forage only sparingly by lake trout, *Salvelinus namaycush* (Wright 1968), and yellow perch, *Perca flavescens* (unpublished data, Great Lakes Fishery Laboratory).

Recently, a demand for life history information on nearshore fish species of the Great Lakes has arisen in connection with a need to assess possible damage to fish stocks by the increasing numbers of powerplants. Published information on the spottail shiner in the Great Lakes has been limited to a discussion of its seasonal depth distribution in southeastern Lake Michigan (Wells 1968), and a study of its age, growth, and food in Little Bay de Noc, northern Lake Michigan (Basch 1968). The present report describes some aspects of the life history of the spottail shiner, mainly in southeastern Lake Michigan, but also in the Kalamazoo River (a tributary of southeastern Lake Michigan) and western Lake Erie.

MATERIALS AND METHODS

All spottail shiners from Lake Michigan were caught in the vicinity of Saugatuck, Mich. Most were collected with a bottom trawl (12-m headrope; 1.3-cm mesh cod end) fished from the U.S. Bureau of Sport Fisheries and Wildlife R/V *Cisco*. The trawls provided 782 specimens in 10 collection periods during March–October 1964; 465 in 4 periods during July–October 1970; and 155 in 4 periods during July–September 1972 (table 1). The net was towed along a depth contour at a speed of 2.6 knots. Fish were trawled from the bottom at depths of 3–17 fathoms, most from 3–7 fathoms. An additional 40 fish

TABLE 1.—*Numbers of spottail shiners collected, by locality, date, and gear*

Locality, year, and gear	Date																Total
	March	April		May		June		July		August		September		October			
	1–15	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31		
Lake Michigan:																	
1964, trawl	30	85		224	179	35	73	28	20		83			25			782
1970, trawl								148	16			202			99		465
1972, trawl								43		23	64	25					155
1972, seine								29	11								40
Kalamazoo River:																	
1964, trawl					45	115		44									204
1973, trawl								59									59
Lake Erie:																	
1958, trawl		162	159	62	24	305		30	312	136	283	108	48	403	192		2224
1958, seine								221	276		196						693

were obtained with a beach seine (15.2 m long, 1.3-cm mesh) in July 1972 (table 1). All fish collected in 1972 were females, and were used only in delineating the spawning season.

Kalamazoo River spottail shiners were taken with a bottom trawl (5-m headrope; 1.3-cm mesh cod end), also fished from the R/V *Cisco*. Collection stations were in the stream channel (depth 4 m), about 1, 2, and 3 km from the mouth; fish from the three areas were combined for all analyses. The samples included 204 fish taken in three collection periods during May–July 1964, and 59 taken in July 1973 (table 1).

Spottail shiners were collected from Lake Erie by three methods: with the large trawl described above, fished from the R/V *Cisco;* with a smaller trawl (8.5-m headrope; 1.3-cm mesh cod end) fished from the Bureau's R/V *Musky II;* and with the beach seine described above. Trawled specimens were from 15 widely scattered stations, ranging in depth from 3 to 6 fathoms, in the western basin. A single seine station was in the western basin near Sandusky, Ohio. All collections were made in 1958. A total of 2,224 fish were sampled during one to nine (average three) visits to the various trawl stations during April–October and 693 were caught on three dates at the seine station (table 1). The seine-caught fish were used only in determining seasonal growth of young-of-the-year. Few fish of other ages were caught.

Fish from all three bodies of water were preserved in 10 percent formalin and processed later in the laboratory. The following data or materials were taken from each fish in the Lake Michigan and Kalamazoo River samples: total length to the nearest millimeter (tip of snout to tip of caudal fin with lobes compressed), weight to nearest 0.1 g, sex, state of maturity, and scale sample for aging and back calculation of growth. A fish was judged to be mature if it appeared that it would spawn during the following spawning season. The scale samples from 774 Lake Michigan fish and 103 Kalamazoo River fish were taken from "key" areas for determination of body-scale relations. Scale measurements for the calculation of growth were recorded to the nearest millimeter at each annulus along the anterior radius. Data and materials for Lake Erie fish included total length, sex, state of maturity, and a scale sample from each of 1,778 caught in trawls; only total length was recorded for the rest of the fish caught in trawls and all those taken in seines; we took no scale samples from trawl-caught young-of-the-year.

DEPTH AND TEMPERATURE DISTRIBUTION

The spottail shiner in Lake Michigan in late spring and summer is usually confined to depths of 7 fathoms and shallower, at

temperatures of 13 C. to the highest available; in winter it may be found commonly to 17 fathoms and sparingly to 25 fathoms (Wells 1968). Wells (who lacked length and age data for the species) reported that heavier fish tended to be in deeper water. The present study shows that fish in deeper water tended to be longer and older. On September 2, 1970, for example, the average lengths of males at 3 and 7 fathoms were 81 and 106 mm, and of females 80 and 118 mm. Average ages at these respective depths were 1.2 and 1.6 for males and 1.1 and 2.5 for females. The bottom water temperatures at 3 and 7 fathoms were 19.5 and 13.1 C., respectively, suggesting that the differences in distribution may have been related to temperature. Even when temperatures were not markedly different at 3 and 7 fathoms, however (e.g., 14.8 and 13.3 C. on 26 May 1964), fish in the deeper area were of the greater average age and size.

The depth and temperature distributions of spottail shiners in western Lake Erie were generally similar to those in southeastern Lake Michigan. In Lake Erie the species also preferred the shallower, warmer water, and small fish tended to inhabit shallower water than larger ones. Seine catches contained a much higher proportion of small shiners than did trawl catches. Length distributions of the seined fish indicated that 664 of 693 were young-of-the-year. Lake Erie spottail shiners, although essentially bottom fish as in other waters, occasionally have been taken in midwater trawls at night (unpublished data, Great Lakes Fishery Laboratory).

AGE COMPOSITION AND SEX RATIO

Spottail shiners in the Lake Michigan samples ranged from ages 0 to V, but most were in age groups I–IV (table 2); the numbers decreased sharply in age groups IV and V in both 1964 and 1970. The age composition of fish in the samples was not altogether representative of the population, inasmuch as our sampling did not completely take into account the uneven depth distribution by age. Small fish probably were poorly represented in the samples because disproportionately large numbers were in water too shallow to be sampled by the trawls—and also because they might not have been fully vulnerable to the nets. Although catches of older fish may not have been entirely representative either, there seems little doubt that the abrupt decline after age III of fish in the samples reflects high mortality. Sex ratio of younger fish was not consistent in the 2 years of collection; at ages greater than II, however, females were progressively more abundant than males (table 2), indicating greater mortality among the males.

Collections in the Kalamazoo River, especially in 1973, were too small for conclusions regarding age composition and

TABLE 2.—*Age distribution of spottail shiners in collections from southeastern Lake Michigan (1964 and 1970), the Kalamazoo River (1964 and 1973), and western Lake Erie (1958)*

Age group	Southeastern Lake Michigan				Kalamazoo River				Western Lake Erie	
	1964		1970		1964		1973		1958 [1]	
	Number of fish	Percent female	Number of fish	Percent female	Number of fish	Percent female	Number of fish	Percent female	Number of fish	Percent female
0	3	67	82	54	0	----------	0	----------	809	[2] 46
I	52	48	165	57	3	67	0	----------	796	56
II	259	59	81	47	114	48	10	30	508	87
III	354	71	99	71	56	57	23	30	83	98
IV	101	80	34	82	31	35	26	31	28	100
V	13	85	4	100	0	----------	0	----------	0	----------

[1] Includes only trawl samples.
[2] Sex ratio based on 363 fish; sex of remainder not determined.

sex ratio. The data suggest, however, that the river fish do not live as long as Lake Michigan fish: Age group II was commonest in the river catches (1964 and 1973, data combined), and no fish older than age IV were caught (table 2). Although sex ratios were inconsistent and perhaps not closely representative of the population, the data suggest that females did not outnumber males among older fish, as they did in Lake Michigan.

Spottail shiners have a shorter life span in western Lake Erie than in southeastern Lake Michigan. Most females in the Lake Erie samples were in age groups 0–II, and none were older than age IV; most males were in age groups 0 and I, and none exceeded age III (table 2). An abrupt decline in the ratio of males to females in successive years after age I indicates that differential survival favoring females is even more pronounced in Lake Erie than in Lake Michigan.

ANNUAL GROWTH

Growth during each year of life for Lake Michigan fish was calculated by the "scale" method, as described by Hile (1970). For determining the body-scale relation of Lake Michigan spottail shiners, we used three "key" scales from each of 774 fish (47–142 mm long) collected in 1964 and 1970. These were taken from the third scale row above the lateral line—the first scale from directly below the anterior insertion of the dorsal fin and the other two immediately posteriad. Although Smith and Kramer (1964) reported a notable difference in body length-scale length regressions of the sexes for spottail shiners from Lower Red Lake, statistical tests of our data showed no such difference; consequently we calculated a regression for sexes combined. A straight line was fitted by least squares to a plot of the weighted mean fish lengths and mean scale radii for 5-mm length groups of fish (fig. 1). The equation of the line is:

$$L = 14.6 + 0.55\ S,$$

where L = total length of fish in millimeters, and S = scale radius (mm × 80). The y-intercept of 14.6 mm agrees well with the 14.2 reported by McCann (1959) for spottail shiners from Clear Lake, Iowa, and falls about midway between Smith and Kramer's (1964) values of 11.0 and 17.0 for males and females, respectively, from Lower Red Lake.

Growth patterns of spottail shiners taken in Lake Michigan in 1964 and 1970 were different. Fish in the 1970 collections, as compared with those in 1964, grew significantly slower ($p = .05$, both sexes) in their first year, but significantly faster ($p = .01$, both sexes) in their second and third years. By the end of their third year the 1970 fish had more than overcome their earlier size disadvantage. Growth after the third year apparently was similar in the two collections (table 3). No explanation is offered for this apparent change in growth patterns. It would not seem to be attributable to variations in the suitability

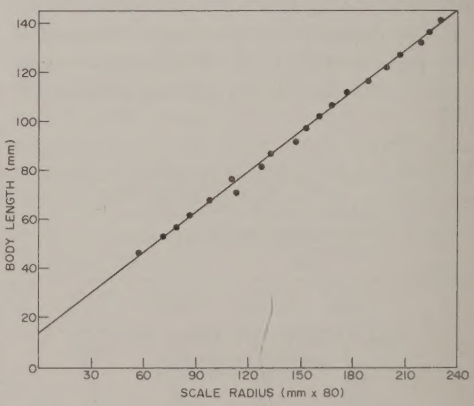

FIGURE 1. Body-scale relation for spottail shiners from southeastern Lake Michigan, 1964 and 1970 (data combined).

TABLE 3.—*Calculated total length of spottail shiners at end of each year of life, southeastern Lake Michigan, 1964 and 1970 (data combined), and mean length increments for 1964 and for 1970.*

Age group	Number of fish	Sex	Length at capture	Length (mm) at end of year of life				
				1	2	3	4	5
I	98	M	77	60				
	119	F	80	60				
II	148	M	100	66	97			
	192	F	101	68	99			
III	131	M	110	61	95	109		
	322	F	115	61	98	114		
IV	26	M	118	59	87	106	117	
	109	F	124	61	95	112	123	
V	2	M	129	50	92	108	119	129
	15	F	131	62	96	111	123	131
Mean of calculated length		M		62	95	108	117	129
		F		63	97	114	123	131
Mean of length increment		M		62	32	15	11	10
		F		63	34	17	11	8
Mean of accumulated length increments		M		62	94	109	120	130
		F		63	97	114	125	134
Mean of length increments, 1964		M		65	30	14	11	10
		F		64	34	16	11	7
Mean of length increments, 1970		M		58	37	18	11	
		F		59	36	21	13	10

of growing seasons, since the differences were consistent through all year classes.

To attain a general representation of growth of spottail shiners in southeastern Lake Michigan, we combined the data from the 1964 and 1970 collections (table 3). Growth was much more rapid in the first year of life than in subsequent years; declines in growth were particularly evident in the second and third years. Females grew slightly faster than males in the earlier years. On the basis of the means of the accumulated length increments, the respective lengths of males and females at the end of the third year were 109 and 114 mm. The growth advantage of females did not seem to increase after the third year. Smith and Kramer (1964) observed that female shiners grew faster than males at all ages in Lower Red Lake.

Growth of Kalamazoo River spottail shiners was also calculated from scale measurements. The calculations were based on the body-scale relation derived for Lake Michigan fish. We followed this procedure because the Lake Michigan "key" scale samples were considerably larger and contained a wider range of fish lengths. Moreover, a preliminary comparison of the data from the lake and the river had indicated that the body-scale relations of the fish in the two areas were closely similar. Any errors which might have resulted are believed to be slight.

Although the spottail shiners from the Kalamazoo River in 1973 were too few (59 specimens) for a detailed comparison of their growth with that of fish from the river in 1964, preliminary analysis of data from the two collection years suggested that growth patterns were similar except for the first-year increments for age-IV fish. The increments of 44 and 42 mm for males and females in the 1964 collections were significantly less ($p = .01$, both sexes) than the 59 mm for both sexes in the 1973 sample. The difference may simply reflect substantially later hatching or poorer growing conditions in 1960 than in 1969, the respective years of hatching for the two groups of 4-year olds. For the 2 collection years combined, growth of Kalamazoo River spottail shiners decreased rapidly after the first year, to the extent that growth in the first year more than equalled the total for the next three. Growth increments for males in the first through fourth years were 54, 25, 16, and 11 mm, respectively; females apparently grew slightly faster (table 4). The slower average growth rates in the Kalamazoo River than in Lake Michigan, at least in

TABLE 4.—*Calculated total length at end of each year of life of spottail shiners from the Kalamazoo River, Michigan, 1964 and 1973 (data combined)*

Age group	Number of fish	Sex	Length at capture	Length (mm) at end of year of life			
				1	2	3	4
I	1	M	61	53			
	2	F	62	53			
II	66	M	82	57	81		
	58	F	84	58	82		
III	40	M	92	51	76	91	
	39	F	95	56	79	95	
IV	38	M	106	51	78	95	106
	19	F	105	49	77	93	105
Mean of calculated length		M		54	79	93	106
		F		56	80	94	105
Mean of length increments		M		54	25	16	11
		F		56	24	16	12
Mean of accumulated length increments		M		54	79	95	106
		F		56	80	96	108

the first 2 years of life, suggests that populations in the two areas are to some degree distinct. The possibility of some movement of lake fish into the river cannot be ruled out, however, since size ranges at a given age overlap among fish of the two bodies of water.

Growth rates of spottail shiners of western Lake Erie were determined by calculating average lengths at capture of various age classes before they had begun growth in 1958. Samples used for this purpose were collected April 22–June 24, and included 185 males and 527 females. The oldest males had completed 2 years of growth, and the oldest females, 4 years (table 5). Growth in the first year was rapid, females and males attaining lengths of 78 and 76 mm. The size advantage of females had increased by the end of the second year, when lengths were 108 mm for females and 101 for males.

Spottail shiners in their first 3 years of life grew faster in Little Bay de Noc of northern Lake Michigan (Basch 1968), Clear Lake, Iowa (McCann, 1959), and Lower Red Lake, Minnesota (Smith and Kramer, 1964), than in the Kalamazoo River, but slower than in western Lake Erie and southeastern Lake Michigan (fig. 2). Growth of Clear Lake fish in the first year was rapid—equal to that of Lake

TABLE 5.—*Length distribution of various age groups of spottail shiners collected in western Lake Erie, April 22–June 24, 1958* [1]

Total length (mm)	I		II		III	IV
	M	F	M	F	F	F
50–54	2					
55–59	1	1				
60–64	4	5				
65–69	24	16				
70–74	32	38				
75–79	33	40				
80–84	26	32				
85–89	25	29		1		
90–94	2	6	5	10		
95–99			8	29		
100–104			17	44		
105–109			5	80		
110–114			1	81		
115–119				38	6	
120–124				4	18	
125–129					21	2
130–134					6	9
135–139						9
140–144						2
Total fish	149	167	36	287	51	22
Average length	76	78	101	108	125	135

[1] No males older than age II were collected.

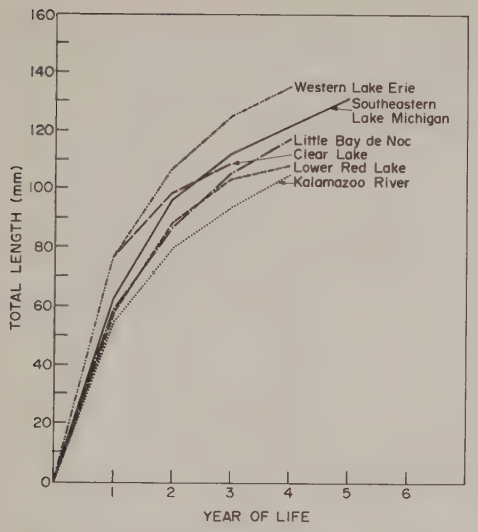

FIGURE. 2. Annual growth of spottail shiners in certain waters of the Midwest. (See text for sources of data.)

Erie—but decreased greatly in later years. The average lengths (millimeters) of fish (sexes combined) at the end of the third year in the different waters were as follows: western Lake Erie, 125; southeastern Lake Michigan, 112; Clear Lake, 108; Little Bay de Noc, 105; Lower Red Lake, 103; and the Kalamazoo River, 95.

SEASONAL GROWTH

Young spottail shiners tended to start growing earlier in the year than older ones, in all three waters studied. The difference in time may be less than the data suggest, however, because new growth probably could be detected on the scales of young fish sooner than on the scales of the much slower-growing older ones. Males and females of the same age seemed to begin growing about the same time.

In Lake Michigan in 1964, no fish had initiated growth by June 14. A few fish of age II, but no older ones, had begun by June 21. Most II-group fish and nearly half of the III group were growing by July 7. Some III- and IV-group fish had not resumed growth by late July, but all had started growing by August 21. Scanty evidence suggests that all age groups grew considerably in September, but that all had stopped by mid-October.

Our data on time of resumption of growth of spottail shiners in the Kalamazoo River are limited. We may state with confidence, however, that growth in 1964 began earlier in the river than in the lake. Among fish from the river, a few of age II were growing by May 20–24, and some of age III began shortly thereafter. Although no age-III fish had started on June 1, 75 percent had added new growth on June 11–12.

Among Lake Erie spottail shiners, none collected on June 24 had begun growing, although unpublished data of the Great Lakes Fishery Laboratory show that in samples taken on June 14, 1957, a few age-I fish had already added new growth. By July 14–18 all fish of age I, 87 percent of age II, 62 percent of age III, and 50 percent of age IV had begun growing. Data on growth increments at different times of year indicated that growth ceased in late September or early October. Increments increased little between September 10–21 and October 22–27, our next (and last) sampling period (table 6). On the assumption that growth had ended by October 22–27, fish of ages 0–III had completed 95, 88, 100, and 90 percent of their seasonal growth by September 10–21.

LENGTH-WEIGHT RELATION

Determination of the length-weight relation of southeastern Lake Michigan spottail shiners is based on all collections combined. The length-weight equation, determined by fitting a straight line to the logarithms of the average lengths and

TABLE 6.—*Growth in length (mm) and (in parentheses) percentage of season's estimated total growth completed on various dates in 1958, for different age groups of spottail shiners in western Lake Erie*

Age group	Date					
	June 24	July 14–18	August 1–9	August 21–29	September 10–21	October 22–27
0	0	34(44)	50(68)	51(69)	70(95)	74(100)
I	0	10(29)	22(65)	24(71)	30(88)	34(100)
II	0	4(29)	6(43)	10(71)	14(100)	14(100)
III	0	1(10)	1(10)	4(40)	9(90)	10(100)

weights for each 5-mm interval of fish length is:

$$W = (0.343 \times 10^{-5})\ L^{3.217}$$

where W = weight in grams and L = total length in millimeters. Agreement between empirical and calculated weights for various length groups was close for all sizes of fish (fig. 3).

The length-weight relation of spottail shiners of the Kalamazoo River was about the same as for those of Lake Michigan at smaller sizes. But, above a length of about 100 mm, the river fish were lighter than those of Lake Michigan. For example, average empirical weights for Kalamazoo River and Lake Michigan fish 100–104 mm long were 8.6 and 9.6 g, respectively, and for fish 110–114 mm long, 10.8 and 14.0 g.

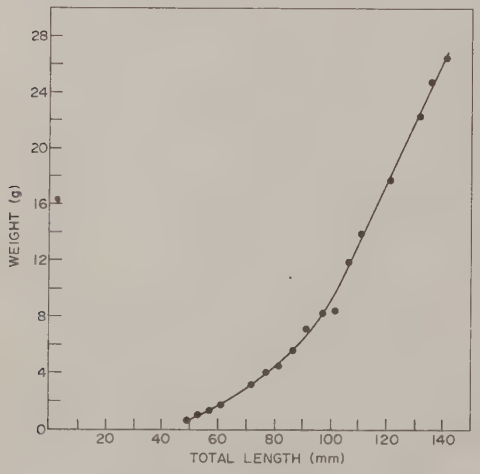

FIGURE 3. Length-weight relation of spottail shiners from Lake Michigan.

Weight data are lacking for Lake Erie specimens.

REPRODUCTION

Size and age at maturity.—Analysis of collections taken near the beginning of the spawning seasons in southeastern Lake Michigan (1964 samples only), the Kalamazoo River (1964), and western Lake Erie, indicated that in all three areas spottail shiners matured at about the same length, and males at a somewhat smaller size than females. Ages at maturity, however, varied according to growth rates in earlier years. The smallest mature fish were 65–69 mm long (except for a 59-mm individual in Lake Erie), and the largest immature fish were 80–84 mm. In Lake Michigan, 53 percent of the males and 40 percent of the females of age I, and all fish of age II, were mature. In the Kalamazoo River, where early growth was slow, only 88 percent of the males and 76 percent of the females of age II were mature. All fish of age I (3 fish) were immature, and all those of age III were mature. In Lake Erie, where early growth was fast, 78 percent of the males and 63 percent of the females of age I, and all fish of age II were mature. Our findings agree well with those of Peer (1966), who, on the basis of original work in two Saskatchewan lakes and inferences from the literature, concluded that spottail shiners mature only after they have reached a total length of about 68 mm, and that age at maturity is a function of growth rate.

Spawning depth and season.—We did not determine the exact depths or localities of spawning in any of the waters. Catches in trawls (Wells 1968) and beach seines showed that most spottail shiners in southeastern Lake Michigan were at depths from near shore to 5 fathoms during the spawning season. Some evidence suggests that spawning was heaviest in the shallow portion of that depth range. Of females caught July 1, 1970, 22 percent were spent where the depth was 3 fathoms, as compared with only 2 percent at 5 fathoms. Among mature females collected in beach seines in 1972 (a year in which spawning was late, as described later) 10 percent on July 11 and 64 percent on July 20 were spent; in samples from trawls, however, none (of 43 fish) on July 12 (5 fathoms) and only 30 percent on August 2 (3 fathoms) were spent. It thus appears that many fish move into the shallowest areas just before spawning. Inasmuch as all shiners were collected from sandy bottom, where spawning was obvious, we cannot say whether the species spawns over other bottom types as well.

Spottail shiners were observed in southeastern Lake Michigan spawning at a depth of 2½ fathoms on top of a water intake crib located where the bottom depth was 5 fathoms. The observations were made by John Dorr, Thomas Bottrell, and Sue Williams of the University of Michigan Great Lakes Research Division (personal communication) while skindiving at dusk on June 17, 1973, off the Cook powerplant, about 76 km south of Saugatuck. Several females were seen depositing eggs in patches of *Cladophora*, about 4 cm high, growing on the crib. An estimated 500–1,000 males and females, most apparently ripe, were above and in the *Cladophora*.

The exact progress of the spawning season of spottail shiners is somewhat difficult to follow from our data because our samples were not collected at regular, closely spaced time intervals, and because, at least in Lake Michigan, the proportion of the population which had spawned on a given date varied with depth of capture. The data, however, are adequate to permit general conclusions regarding the spawning season. The spawning season in Lake Michigan (and no doubt in other waters) varies from year to year depending on water temperature. In 1964, no spawning had occurred on June 21, but about 75 percent of the fish in our samples had spawned by July 7, 93 percent by July 28, and all by August 21. In 1972, in contrast, spawning apparently did not begin until near mid-July, peaked in late July or early August, and ended in late August or early September. Water temperatures, which rose later than usual in 1972 and delayed spawning of yellow perch and alewives, *Alosa pseudoharengus* (unpublished data, Great Lakes Fishery Laboratory), probably also caused the later spawning of spottail shiners in 1972 than in 1964. Spawning occurred from mid-June to mid-July in 1967 in Little Bay de Noc, northern Lake Michigan (Basch 1968). In the Kalamazoo River, spawning had not begun by June 1, 1964, but most fish were spent by June 15, and all by July 1. Spawning in Lake Erie in 1958 began in early June, was at its peak in mid-June (78 percent of those collected June 19–24 were spent), and was completed by early or mid-July. Fish (1932) found spottail shiners spawning along the shore of Lake Erie and its tributaries from late June to early July. McCann (1959) reported that this species spawned in Clear Lake, Iowa, in May (1958).

Fecundity.—Ripe female spottail shiners contain two distinct types of eggs, one yellow and apparently mature, and the other white and apparently immature; only the yellow ones were counted in the present study. Ten mature females from Lake Michigan, 97–131 mm long, and ranging in age from II to V, contained 915 to 3,709 mature eggs (table 7). The

TABLE 7.—*Number of mature eggs in each ovary of prespawning spottail shiners of various lengths and ages, southeastern Lake Michigan, the Kalamazoo River, and western Lake Erie*

Locality	Length of fish (mm)	Age	Number of eggs [1]		
			Left ovary	Right ovary	Total
Lake Michigan	97	II	598	580	1,178
	103	II	433	482	915
	104	II	585	540	1,125
	107	II	753	825	1,578
	113	III	790	784	1,574
	117	III	1,564	1,465	3,029
	117	IV	634	618	1,252
	121	IV	1,050	1,234	2,284
	127	IV	1,910	1,630	3,540
	131	V	1,945	1,764	3,709
Kalamazoo River	92	III	480	475	955
	100	III	590	502	1,092
	105	IV	885	883	1,768
Lake Erie	87	I	1,127	1,133	2,260
	103	II	855	914	1,769
	107	II	1,166	1,144	2,310
	127	III	2,140	2,240	4,380
	143	IV	4,449		8,898

[1] Complete counts.

number of eggs generally increased with increasing length of fish, and the right and left ovaries usually contained about the same number of eggs. Three Kalamazoo River fish, 92–105 mm long, ages III and IV, contained 955 to 1,768 mature eggs (table 7). Four fish from Lake Erie, 87–127 mm long, ages I–III, had 1,769 to 4,380 mature eggs, and a single 143–mm, age-IV, specimen contained an estimated 8,898, based on a count of one ovary.

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